Hydrogen as an Educational Tool: Practical Learning for Future Energy Engineers

E. Iniesta-López, A. Hernández-Fernández, A. Sánchez-Zurano, M. Luisa Hernández, M.A. Sánchez Muñoz, A. Pérez de los Ríos and F.J. Hernández-Fernández

Department of Chemical Engineering, Faculty of Chemistry, University of Murcia (UMU), Campus de Espinardo, E-30100 Murcia, Spain

Abstract

Hydrogen is expected to play a pivotal role in the decarbonization of industry, energy systems, and transport, creating an urgent need for engineers with both theoretical knowledge and practical skills in hydrogen technologies. This work presents an educational methodology designed to enhance undergraduate engineering education through hands-on learning experiences focused on hydrogen production, storage, and utilization.

The proposed methodology combines short theoretical sessions with project-based laboratory activities using a complete renewable hydrogen system. The experimental setup integrates photovoltaic panels, wind turbines, a PEM water electrolyser, hydrogen storage devices, and a proton exchange membrane fuel cell connected to a small electric vehicle. Students actively produce renewable hydrogen via water electrolysis, safely store it, and subsequently use it to power the fuel cell vehicle, enabling them to observe the complete energy conversion process from renewable electricity to hydrogen and back to electrical and mechanical energy. During the practical sessions, students analyze system performance, evaluate energy conversion efficiency, and discuss the role of hydrogen technologies in the energy transition.

The laboratory activities are complemented by discussions on hydrogen production pathways, industrial applications, safety aspects, and sustainability challenges. This educational approach promotes active learning, increases student motivation, strengthens conceptual understanding, and develops critical thinking regarding the technical, environmental, and economic aspects of hydrogen technologies. By bridging the gap between theory and practice, the proposed methodology prepares future engineers to contribute effectively to the deployment of sustainable hydrogen systems and supports the transition towards a low-carbon economy.

Keywords: active learning; fuel cells; hydrogen education; renewable energy; sustainable engineering